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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Specialty Lubricants for Special Machinery

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Specialty Lubricants for Special Machinery

CERTAIN types of machinery operations present distinctive problems in regard to lubrication. Experience has taught the petroleum industry that it is unwise to attempt to solve these with makeshift or substitute products; the responsibility is too great. Hence, the extensive expansion in research and the improvements in refinery practice which have distinguished this industry for far-sighted progress during the past few distressing years of reduced income and intensive competition. Specialty products of petroleum base may cover a wide range. We have a variety of fuels for distinctive types of internal combustion engines, insecticides, wood preservatives, medicinal compounds and, of course, lubricants.

These latter are by far the most important because of their relation to low cost machine production which so often will affect our actual comfort. In this regard it is well to mention air-conditioning, the several intricate types of equipment designed for household service, and the splash-proof ball-bearing motor as outstanding instances of mechanical developments which for continued operation are so vitally dependent upon effective lubrication. It is equipment of this nature with which the petroleum research worker has to deal in the production of specialty lubricants.

In this program of mechanico-chemical research one essential has been especially prominent: resistance to oxidation or chemical breakdown. Petroleum lubricants are of necessity complex, being made up of a variety of hydro-carbon components of organic nature. Some of these react more readily with oxygen than others. Often such reaction is followed by formation of gummy materials or residual sludges which obviously may seriously impair circulation of lubricant or lubricating ability. Fortunately, by certain specialized methods of refining, it has been proved practicable to remove the most active of these oxidizable components to the distinct improvement of the stability of the finished product.

MACHINE MAINTENANCE

The mechanical condition of machinery with respect to wear of moving parts and development of more or less misalignment may often give rise to the apparent necessity for specialized lubrication quite foreign to the type of lubrication originally provided for by the designer. This will usually arise where maintenance has been neglected or where a grade of lubricant has been used which is unsuited to the means of application or the operating speeds, temperature, or load. The past few years of restricted income have led far too many to study first cost as applied to lubricants and completely overlook the potential later effect on machine production and cost of maintenance. It is obvious that such a procedure is false economy. It is, furthermore, a

disturbing factor to the lubricating engineer in servicing such equipment, for it necessitates consideration of lubricants which should normally not be suggested, due perhaps to their viscosity or consistency which might lead to

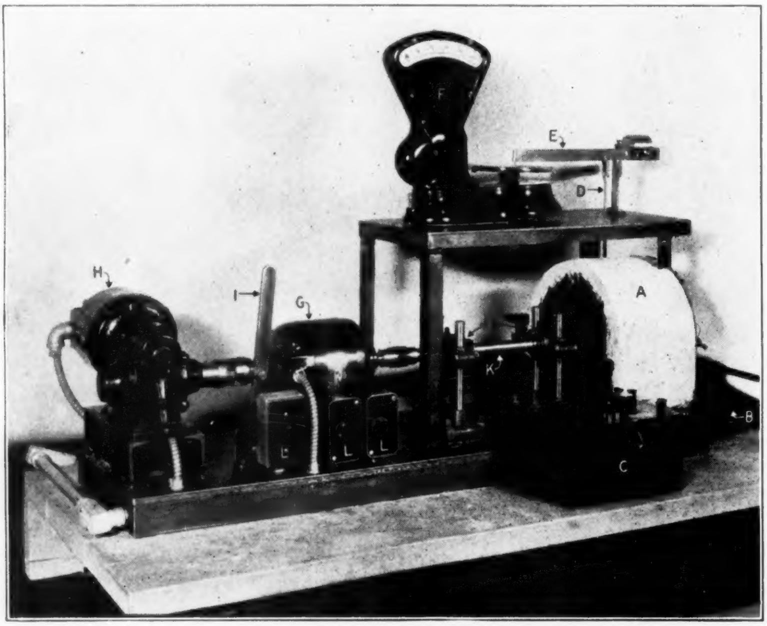


Fig. 1—By testing a grease directly in a bearing under controlled operating conditions of speed and temperature, it is practicable to simulate actual service operation and obtain interesting information as to the behavior of any such type of lubricant. The torque-breakdown machine, as illustrated above, consists of:

A.—An insulated jacket for controlling temperature of test. Test bearing (not visible) is attached to end of shaft K.
B.—$\frac{1}{4}$" line leading to inside of jacket. This carries either steam or cold brine.
C.—Potentiometer for obtaining temperature of outer bearing race.
D. & E.—Levers for transposing torque forces onto platform of gram scale, F.
G.—1750 r.p.m. $\frac{1}{4}$ H.P. induction motor, directly connected to shaft K.
H.—$\frac{1}{6}$ H.P. induction motor geared down to shaft speed of 36 r.p.m.
I.—Clutch lever for driving with either 1750 or 36 r.p.m. Motor H drives through motor G.
J.—Shaft hangers.
L.—Motor starting switches.

By the use of this machine (developed at the Beacon, N.Y., Research Laboratory of The Texas Company) it is practicable to observe relative starting and running torques; leakage; and temperature rise caused by internal friction.

abnormal internal friction and power consumption.

Wear or misalignment will result in increased clearance. In some types of mechanisms this will be relatively unimportant. Wherever accurate process work must be produced, however, or where pressures must be maintained as in the reciprocating engine or compressor, increase in clearance between bearings and shafting, between piston rings and cylinder walls, or alteration of the pitch line of a gear set, may seriously affect the productive efficiency of the entire machine.

In the operation of certain types of gears and roller bearings, misalignment and uneven wear may often cause marked increase in unit bearing pressures, thereby necessitating the use of a lubricant capable of forming a protective film of unusual strength. Provided the design is such as to enable retention of this lubricant at the point of maximum load, there will be a certain amount of added insurance that wear and clearance increase will be retarded. Unfortunately, however, where misalignment of either gears or bearings has occurred, it is very possible that leakage of lubricant will occur so that the pressure of the lubricating system on the film itself cannot be maintained. Under such conditions it is obvious that the expected benefits of extra-film strength may not be fully realized, in view of the inability of the lubricant to remain for a sufficient length of time between the contact parts. So the use of such a product, often at a considerable increase in price above the normally accepted type of lubricant, becomes but a temporary remedy instead of a permanent cure.

In the rehabilitation of machinery, it is, therefore, highly essential to remember that by adopting a repair program which will correct mechanical defects detrimental to effective lubrication, the economical use of lubricants can be more easily accomplished and more permanently maintained. The ensuing year will see an expansive program of industrial and power plant overhaul. Many improvements in bearing design, power transmission equipment, and methods of lubrication have been made over the past few years. Research in the petroleum industry has also proved the practicability of manufacturing both lubricating oils and greases to more nearly meet the mechanical requirements of machine design. The progressive plant engineer will make every effort to correlate these improvements to the benefit of his plant production schedule and reduction in later costs of maintenance.

SPECIALTY GREASES FOR BALL AND ROLLER BEARINGS

Prediction of lubricant performance is of the utmost importance to the bearing manufacturer, the lubricating engineer and the operator. Until comparatively recently the selection of greases for anti-friction bearing lubrication has been carried out more from the viewpoint

of positive lubrication than power economy. The former is, of course, highly essential, but practical research into the comparative power consumption developed by certain types of greases in a rotating ball or roller bearing has indicated some very enlightening data. It has

of size and type conforming to the machinery used in each particular locality. Frequently this stock will involve many bearings which have been grease-packed at the time of manufacture. The length of time replacement bearings of this type may have to be stored may

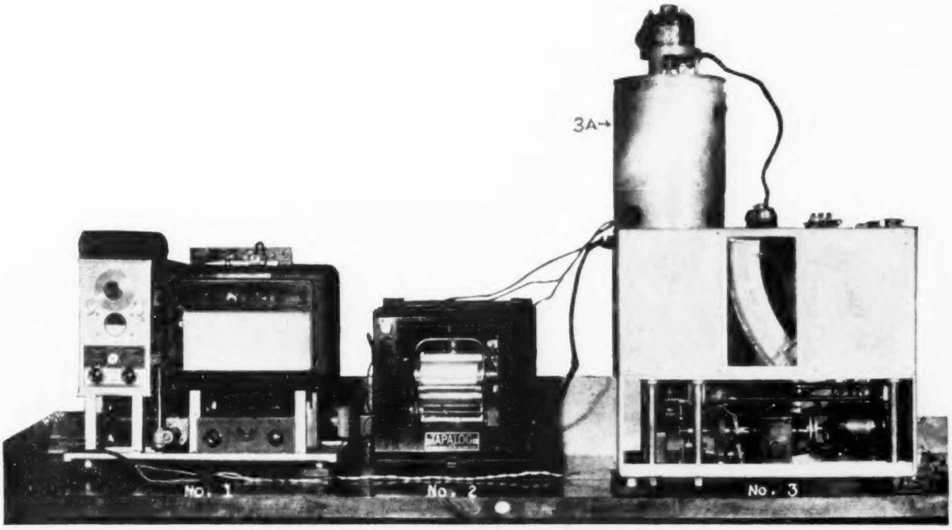


Fig. 2—Showing an apparatus for measuring consistency changes of grease at various temperatures. This device is essentially a flexible penetrometer which measures the resistance of the grease to the passage of the perforated plunger. Part No. 3 contains the automatic constant rate feeding mechanism which forces the perforated plunger through the grease. The test specimen is located in the center of the electrically heated oven, No. 3A. Part No. 2, the temperature recorder, automatically notes room, oven, and test specimen temperatures. Part No. 1 includes the plunger pressure recorder, and a regulating device which automatically raises the temperature of the test specimen at a slow uniform rate.

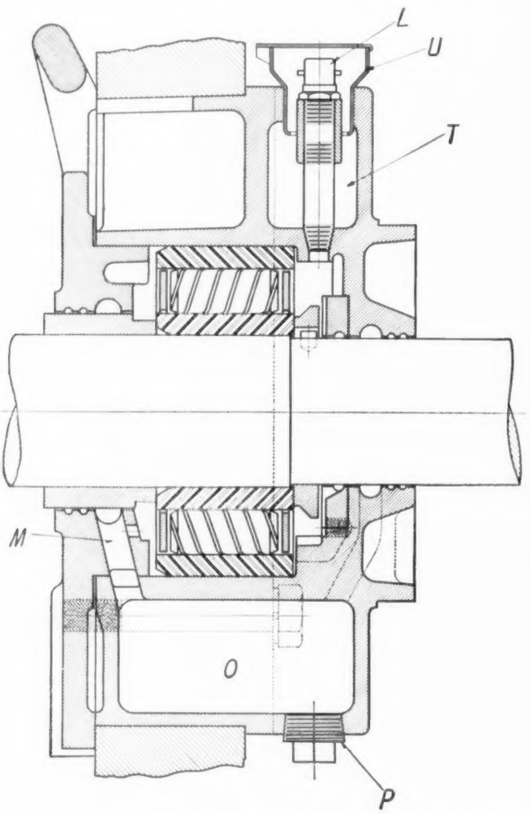
proved the desirability of combining the art of the grease maker with that of the mechanical engineer in the interest of more careful choice of grease ingredients, which will result in a product capable of efficiently resisting separation when subjected to violent agitation and the effect of centrifugal force, with the least expansion due to entrainment of air, and minimum torque or power consumption on starting and during operation. This latter is most desirable in view of the trend towards extended application of the ball bearing to textile machinery where several score bearings may often be involved on certain winders and spinning frames. Obviously, reduction of but a fraction of a horsepower per bearing, by use of a low-torque grease, will have a material effect upon the ultimate power consumption and the size of the driving motor.

Good practice also requires that most careful consideration be given to designing a grease for this service which will effectively resist oxidation and gum formation and thereby relieve the bearing manufacturer of subsequent complaints due to corrosion or sticking of bearings in storage. To meet potential demands for bearing replacement, it is necessary for the manufacturer to keep a considerable stock of such bearings on hand in all branch offices, often be over a year. Obviously, during this period of storage, the grease in the bearing must effectively resist chemical breakdown.

Extensive, long time storage tests, to determine the extent to which method of manufacture or the nature of the fatty oil used may affect such breakdowns, have been carried on by certain of the bearing manufacturers and members of the petroleum industry. These tests have proved that choice of raw materials which are highly resistant to oxidation is a most important adjunct to ultimate stability of the finished grease. Method of manufacture is also believed to be a factor especially in regard to temperature control.

Unfortunately, there is no accelerated oxidation test which will predict the tendency of a grease to oxidize and develop resinous gummy matter on such a bearing during storage. The long time storage tests have proved, however, that certain types of grease are decidedly unfit for extended lubrication of either the ball or roller bearing. It has been somewhat of a process of cut and try to eliminate those factors which have been judged to be objectionable. Sufficient time has elapsed, however, to convince one that this program of long-time storage has been well worth while in enabling the bearing manufacturer to decide more depend-

ably upon the type of grease which will maintain its original lubricating ability and resist chemical change where more or less exposed to air and moisture in a bearing stored under normal conditions.



Courtesy of Westinghouse Electric & Manufacturing Company

Fig. 3—Showing new Westinghouse mill type motor roller bearing housing arranged for grease lubrication. L indicates lubricator fitting with accessory equipment for carrying grease to the outer end of the bearing housing. At the inner end of this housing an escape port for surplus grease is shown at M. This surplus can accumulate in reservoir O, from which it can be removed periodically through outlet P.

Resistance to Flow

There is, of course, a direct relation between the rate of change in physical characteristics of a grease with temperature or pressure and its performance in service. Change in consistency which would be comparable with change in viscosity in an oil has prompted a number of investigators to attempt to develop a method of determining the viscosity of greases or their resistance to flow, as a guide to prediction of the temperature range over which any such product should be used, and the relation of torque, or power consumption, through internal friction.

The research work of Dr. Bingham and M. H. Arveson in the study of viscosity determination of very viscous substances such as greases, and the design of actual equipment for such measurements is particularly noteworthy. Both employ pressure for the acceleration of the flow of material through their respective machines. In this regard, Dr. Bingham has found that "in the measurement of plasticity . . . high pressures give data which may be handled more simply than the data at low pressures."*

Arveson†, in turn, has shown that the apparent viscosity of a grease varies with the rate of shear and that it may be accurately measured in a constant shear viscosimeter. This device involves a piston which is driven mechanically at a constant rate into a cylinder. The sample under test is forced downward against a mercury bed and out through a capillary tube mounted in a removable support.

Mercury is displaced through a duct to the gauge until equilibrium is reached, at which time all the flow is through the capillary. The rate of efflux is thus predetermined by the speed of the piston and the bore of the cylinder, and pressure may be read as frequently as desired. This gives a continuous direct means of observing the conditions existing in the capillary.

Other investigators such as Herschel‡, Bulkley and Bitner§ have worked towards a type of consistometer which will enable one to work out flow-pressure diagrams. The latter hold a particular advantage for this type of machine in the study of materials which change rapidly in consistency with time, or which show a breakdown of structure with mechanical working.

Any device for determination of change in consistency or viscosity with pressure or temperature involves a static test. In realization of this fact, there has been an interesting trend among still other practical investigators toward development of a testing machine which will enable visual observation of the behavior of a grease under actual service conditions. Details of two such machines for the study of breakdown tendency and torque, or power consumption, in grease lubricated ball or roller bearings were discussed in LUBRICATION for July, 1934. Since then a composite machine has been built which enables these observations to be obtained simultaneously with suitable data for plotting of torque curves for any comparatively plastic grease, in terms of gram-centimeters. These data are obtainable under service temperature conditions. (See Fig. 1.)

Actual service tests on greases especially devised for ball and roller bearing lubrication have shown a most interesting agreement with the data and observations made on the same

* E. C. Bingham, "Fluidity and Plasticity," pp. 77-78, 320-323. McGraw-Hill Book Co., 1922.

† M. H. Arveson, Oil and Gas Journal, March 31, 1932, p. 96.

‡ W. H. Herschel, Journal of Rheology, Oct., 1929, pp. 68-75.

§ R. Bulkley and F. G. Bitner, Bureau of Standards Journal of Research, Vol. No. 5, pp. 83-96.

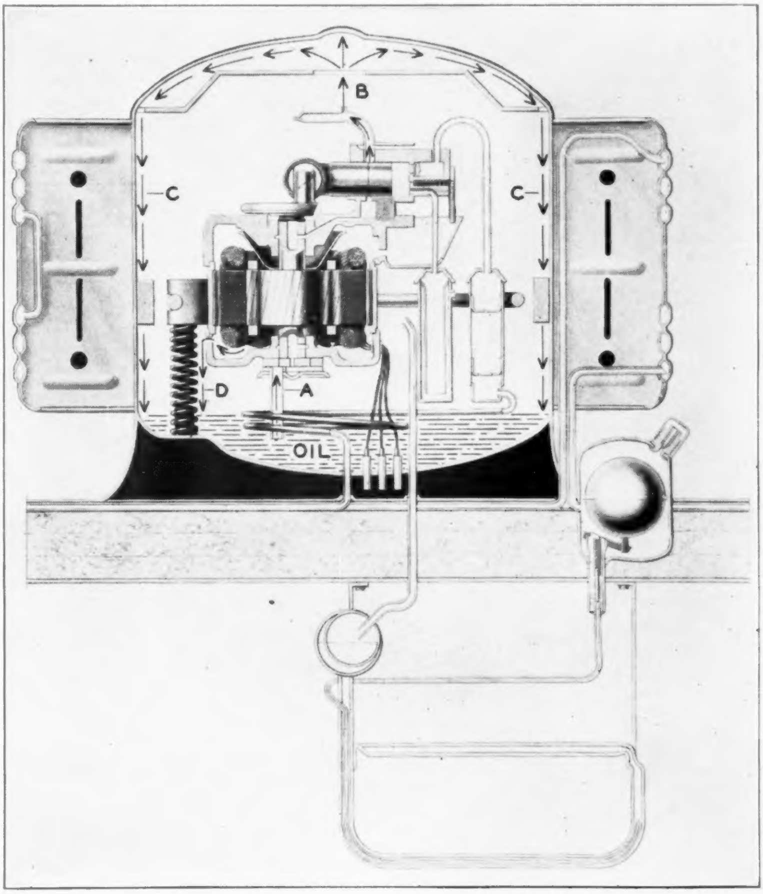
products on the so-called Torque-Breakdown Machine. They have proved conclusively the value of correlating laboratory research with practical service in the study of refinery practices incident to manufacture of specialty greases and other lubricants designed for intensive duty.

In the study of torque characteristics of various types of grease, the data developed by this Torque-Breakdown Machine has checked with Arveson's statement that: "while the initial torque of ball bearings freshly filled with the proper grease was dependent upon the consistency—in other words, on apparent viscosity at low rates of shear—the torque and rise in temperature at equilibrium conditions were primarily dependent upon the viscosity of the oil in the grease."* Later research has proved, in addition, that torque is also materially affected by the method of manufacture.

TEMPERATURE

Temperature of operation has a decided influence upon the performance of any lubricant. Extremes of temperature call for specialty lubricants just as do extremes of speed, or contact with certain types of chemicals. In consideration of low temperature service one of the most interesting studies has dealt with refinement of lubricants for service in air conditioning and household refrigeration machinery. The refinery research chemist has had to study maintenance of lubrication at comparatively low temperatures as well as possibility of chemical reaction or physical solution with the refrigerants used. It has been a most interesting study, for throughout he has had to guard against oxidation and the development of sludge formations. In fact, resistance to oxidation has become one of the paramount features in an oil for such service.

*M. H. Arveson, Oil and Gas Journal, March 31, 1932, p. 167.



Courtesy of General Electric Company

Fig. 4—Detailed view of the Monitor Top section of the General Electric refrigerating unit. Lubrication of this element is of distinct interest. Oil is carried in the base of the machine. Circulation of oil from points "A" and "B" is as follows: A small rotary oil pump located on the end of the shaft carries oil up through this hollow shaft and then through a by-pass to the compressor. Oil is also carried to the crank through a hole running from the main shaft to the side of the crankpin. When the oil leaves the compressor, part of it is discharged vertically at a point marked "B", flowing upward and outward as indicated by arrows and following along the walls of the housing to return to the base. The remainder of the oil from the compressor flows out of another opening over the end of this part of the machine. This oil serves to cool the compressor and particularly the valves. The overflow spills into a cup which carries it to the motor compartment to flood and cool the windings. Small holes in the stator allow the oil to drain to the lower winding compartment, from which it spills through an overflow hole and returns to the sump as indicated at "D".

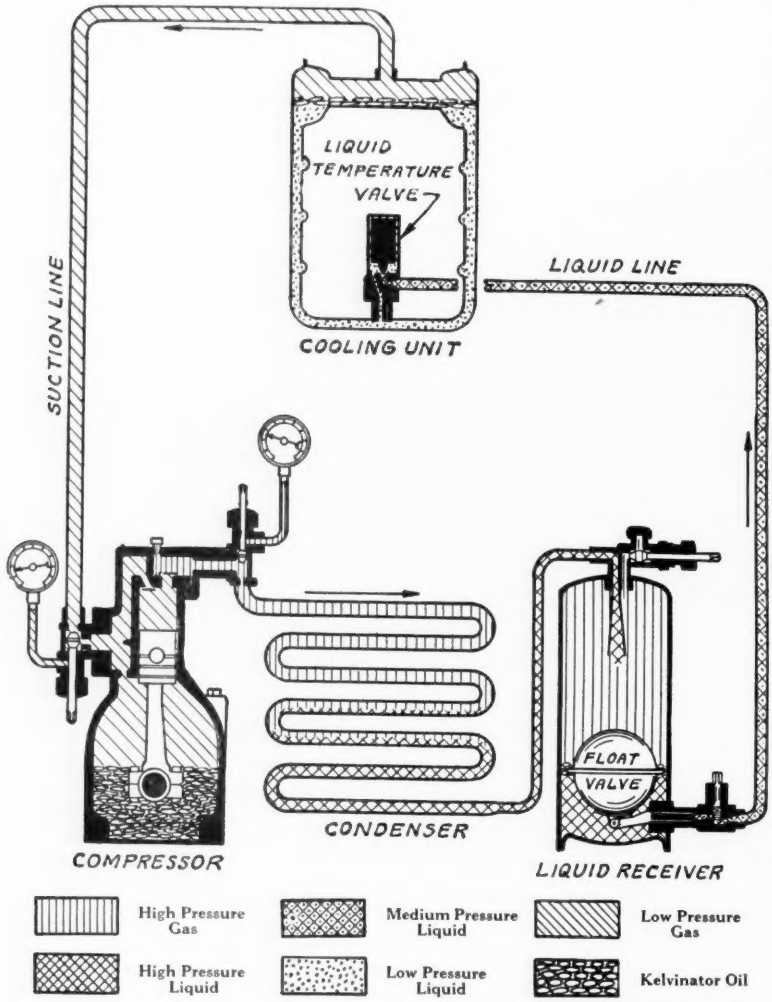
Refrigeration and Air Conditioning

Of the several chemicals used as refrigerants in air-conditioning and refrigeration, sulfur dioxide, methyl chloride and Freon (dichlorodifluoromethane), or F-12 require the most careful attention from the viewpoint of their potential effect upon petroleum lubricating oils.

Sulfur dioxide in the presence of but more than a trace of water will react chemically to form corrosive acids. Where the lubricating oil has not been most carefully refined to render it as chemically stable as possible, there will also be a possibility of breakdown of the hydrocarbon structure of such an oil in the presence of sulfur dioxide. This will result in sludge formation and accumulation of gummy

material which may seriously impair the operation of the unit and especially the distribution of the lubricant.

In air-conditioning work Freon has become



Courtesy of Kelvinator Corporation

Fig. 5—Showing the details of the Kelvinator electric refrigeration system, with the refrigerating cycle and respective locations of high and low pressure gas, high, medium and low pressure liquid, and the lubricating oil.

practically the universal refrigerant. Lubrication of a compressor operating on Freon requires a thorough understanding of the fact that this refrigerant is entirely miscible in straight mineral lubricating oils. As a result of this characteristic of Freon, there is a decided reduction in the viscosity of the ultimate mixture. Until quite recently the trend in the petroleum and refrigerating industries has been to select a lubricant of considerably higher viscosity than would normally be required in the lubrication of compressors of the same capacity operating on any of the other accepted refrigerants.

Lately, however, certain authorities among the manufacturers of air-conditioning machinery in particular have become convinced that the Freon-lubricating oil vapor as developed in the operation of an air-conditioning unit has an appreciable lubricating value. In order to prove this point and to eliminate the possibility of unnecessary increase in power consumption by use of too-heavy an oil, practical study of this problem has recently been undertaken. The data to date indicates that in average railway, commercial or household air-conditioning service, it is advisable to regard approximately 350 seconds Saybolt viscosity at 100 degrees Fahr., as the probable maximum viscosity. Tests on lighter oils have indicated that in all probability even this viscosity can be somewhat reduced, especially if the oil is highly resistant to chemical breakdown.

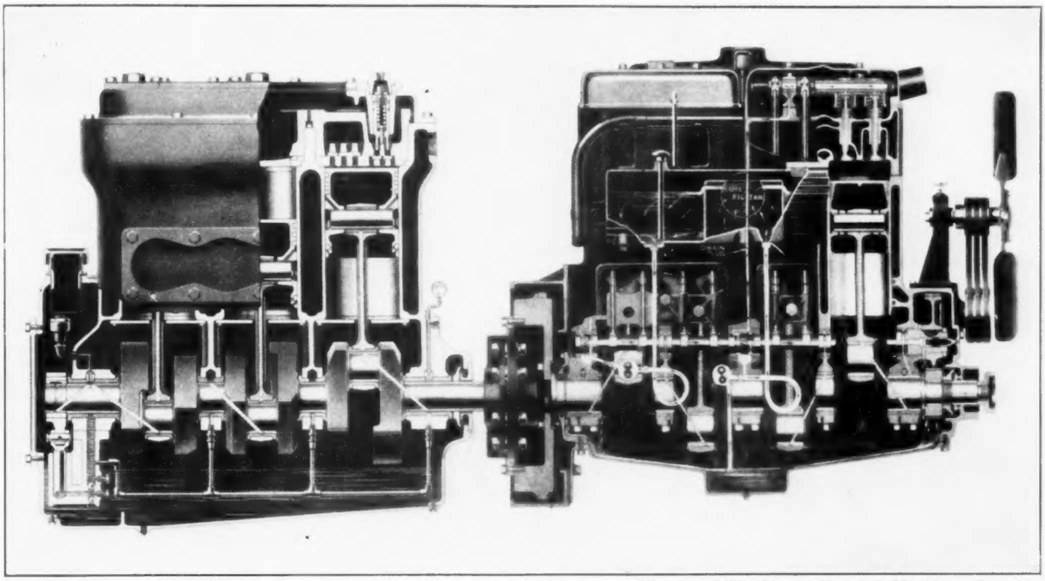
The need for classifying lubricants for such service as above in the category of specialties is enhanced by the desirability of eliminating as far as possible chemical reaction with any of the metals, alloys or fabrics used in the manufacture of the compressor or refrigerating system. In some instances reaction of this sort might be comparatively harmless. In others, permanent damage to the system may result with leakage of perhaps toxic vapors, loss of refrigerant, or at least objectionable odors from certain types of gasket materials. This has called for the development of a variety of bomb tests wherein these materials are exposed to lubricating oil and the refrigerant under operating pressures and temperatures over a considerable period of time. These tests make possible laboratory observation of the ability of the oil under test to withstand breakdown. In effect, this becomes a measure of the degree of refinement, a procedure which has been erroneously over-stressed in the manufacture of certain types of virtually colorless oils for

refrigeration purposes. Advances made in the study of oxidation of petroleum products has indicated that over-refinement increases the susceptibility to breakdown and markedly reduces the lubricating value.

High Temperature Requirements

Wherever machinery is called upon to operate under continued high temperature, that is above an average of 150 degrees Fahr., considerable thought must be given to the heat-resisting properties of all lubricants employed. High temperatures may be either induced as a result of expenditure of electrical energy or development of internal friction between the contact parts or the lubricants used thereon, or, as in steel or cement mill service, heat may be transmitted to the moving parts from the product being handled. Any oil or grease when exposed to varying temperatures will become reduced in body or viscosity as the temperature is increased. It is this fact which renders knowledge of the operating temperature so important.

In consideration of this it is essential to understand thoroughly the course which the lubricant must follow in doing its work. Lubrication can be broadly classified as internal or external according to the intricacy of design. Cylinder lubrication in any type of reciprocating engine, pump or compressor is generally regarded as internal; whereas lubrication of engine or line shaft bearings, gearing, chains or wire rope is classified as external, even though the lubricant must ultimately find its way to enclosed mechanisms if it is to function as intended. The Diesel, automotive and airplane engines present typical examples of cylinder lubrication where high internal temperatures must be met by the lubricating oil.



Courtesy of Worthington Pump & Machinery Company

Fig. 6—Engine and compressor details of the Worthington Portable Compressor. Note that both elements are provided with means for full force-feed lubrication. Design has also been studied to provide adequate means for cooling in order to prevent overheating of the lubricating oil in each unit. Essential details of lubricating system are plainly outlined.

Where lubrication at high temperatures must be maintained by straight mineral or slightly compounded petroleum oils, the extent to which change in viscosity will occur must be carefully investigated. This will depend, of course, upon the range of operating temperatures. With knowledge of these and the normal viscosity of the product at any two standard temperatures, such as 100 degrees Fahr., or 210 degrees Fahr., projection of the viscosity-temperature curve will indicate the probable viscosity at the operating temperature. Relatively speaking, this can be termed a temporary change in viscosity. There will also be a permanent change in viscosity in certain types of petroleum oils which are exposed for any length of time to high temperatures, due to partial breakdown and vaporization of their more volatile components, or, in other words, those hydrocarbon fractions which possess comparatively low boiling points.

METHODS OF TEMPERATURE CONTROL

The satisfactory performance of such lubricants has been insured by development of certain very positive methods of temperature control. It is especially important that this be practiced where high temperature lubrication prevails, in the form of suitable cooling. In

certain types of machine operations where a wide range of climatic conditions may have to be met, heating in cold weather often also becomes highly advisable. Fortunately, the heat transfer coils most frequently installed in such equipment can be used quite as effectively with steam or hot water as with cold water.

Cooling for the purpose of reducing lubricating oil temperatures in the internal combustion engine or the average industrial bearing is most frequently accomplished by water circulation. Air-cooling has been employed to some extent on certain automotive engines, and especially on the radial type of aircraft engine. It will be of further interest to note that oil has also been used for piston cooling purposes on certain Diesel engine installations.

The Adaptability of Water

Water is advantageous for cooling of industrial and automotive equipment for a number of reasons:

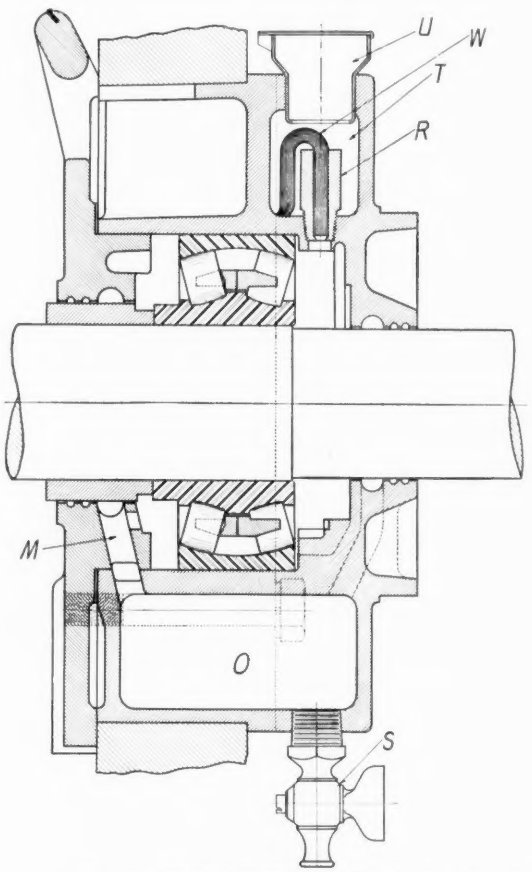
1. It is obtainable in virtually any quantity in most localities at comparatively low cost.
2. It can be handled economically without the need of special equipment.
3. Frequently no precautions are necessary in regard to storage or disposition of waste.
4. It has a high cooling effect because of its high specific heat or ability to take up heat.

There is a distinct disadvantage in the use of water, however, in that should leaks develop between the cooling and lubricating systems undesirable contamination of the lubricant would result. The extent to which this might be detrimental to subsequent operation would depend upon the degree of refinement of the oil and the design of the machine. In the steam turbine, for example, where the highest grade oils are used, water contamination would be a very serious matter. Steam turbine oils must be specially refined to render them capable of resisting emulsification with water, for emulsification and subsequent agitation in the presence of air is the forerunner of sludge formation. Sludge is non-lubricating and frequently of a sufficiently viscous and sticky nature as to lead to obstruction of oil lines, bearing grooves or other parts of the lubricating system. Obviously, this would impair lubrication, due to possible reduction in the circulation of the oil.

Reduction in the rate of oil circulation will also reduce the cooling ability of the oil. This is, of course, only a partial function of the lubricant, but if circulation is maintained at a sufficient rate it will materially aid in reducing bearing temperatures, particularly at the wearing surfaces where over-heating would be most detrimental.

Air as a Cooling Medium

Successful application of air cooling will depend upon the provision for complete circulation of air to the heated parts to bring about adequate heat transfer. As a general rule, air cooling as an adjunct to lubrication is most practicable in connection with moving machinery such as the airplane or automobile engine. Here a natural draft is developed by passage of the engines through the air. On the other hand it is, of course, practicable to develop artificial draft by means of fans or blowers. Unless this draft is led directly to the parts to be cooled, however, much of its intensity and cooling value will be dissipated to the surrounding atmosphere.

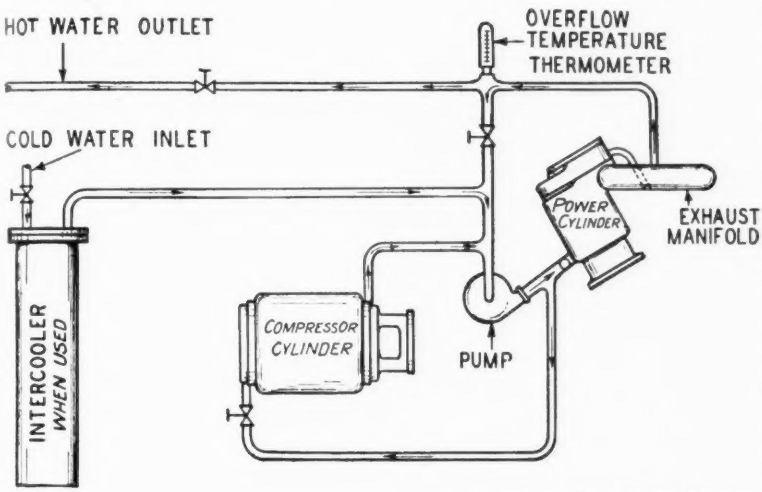


Courtesy of Westinghouse Electric & Manufacturing Company

Fig. 7—The Westinghouse mill type roller bearing motor can also be arranged for oil lubrication. In the above view oil is delivered to the bearing by a felt feed fitting "R". The upper reservoir "T", carries the oil supply introduced through fitting "U". This oil is slowly and continuously syphoned to the bearing through wick "W". Any excess oil runs off through passage "M" to the reservoir "O" in the base, from which it can be removed through the drain cock "S".

The high rate of speed at which the airplane

engine is carried through the air has rendered it almost ideally adapted to air cooling. The radial engine has received the most attention in this regard, due to the arrangement of its cylinders and the fact that each cylinder can be surrounded with an arrangement of fins for air distribution to the exterior walls. Furthermore, inasmuch as all are located in the same plane, air will be distributed equally, and there will be no possibility of any of the cylinders receiving heated air from the others. This is distinctly advantageous as an adjunct to uniform cylinder lubrication.



Courtesy of Ingersoll-Rand Company

Fig. 8—Details of the cooling system of the Ingersoll-Rand gas-engine-driven V-type air and gas compressor. By use of this unique design, temperature differences are eliminated to the interest of improved lubrication.

Oil Cooling of Diesel Engine Pistons

The use of oil as a cooling medium has received quite some attention in Diesel engine design. For this purpose, mineral oils possess the most satisfactory characteristics, in that they will show the least tendency to gum or develop heat-resisting deposits, especially when subjected to wide temperature variations. Mineral oils, however, have a considerably lower cooling ability than water, due to their low specific heat. On the other hand, they possess the distinct advantage in that, should leakage develop, the quality of the lubricant will normally not be materially lowered, especially if the oil which is used for cooling is of sufficient degree of purity.

The construction of virtually all the large high speed engines requires cooling of the pistons. This can, of course, be accomplished by either water or oil. The use of the former has already been mentioned. Oil, in turn, is being given equal consideration, for it is added insurance that lubrication will not be impaired due to the possible development of non-lubricating sludges. Oil as a cooling medium, however, is limited by the design of the piston. This must be such as to insure continuous turbulence of flow within the cooling medium in order to prevent the formation of stagnant heat-resisting films along the walls. Should such films develop, carbon deposits may be formed, especially adjacent to the more highly heated parts of the piston, where there is direct contact with the burning fuel.

Oil in Heat Exchangers

Mineral oil has also been used as a cooling medium in connection with heat exchanger types of lubricating oil coolers. Such equipment is adaptable to steam turbine service, for example, where a considerable volume of oil must be continuously cooled. Here again, mineral oil, even though it may not possess as great a cooling ability as water, will serve to protect lubrication more effectively should leaks develop within the cooler.

Flow of water or oil through a cooling coil or heat exchanger is maintained by gravity or pumping. A number of types of pumps can be employed for this purpose, depending upon the size of the installation and the volume of coolant to be circulated. Under general conditions of industrial plant or engine operation, the gear, rotary or centrifugal pump is used. The reciprocating piston or plunger pump is, of course, also adaptable, but in view of the fact that it will normally require steam for its operation it is not always applicable where oil cooling is practiced.

Any type of circulating pump can be driven either directly by the machine which it serves, by an independent electric motor, or by some other means of power transmission. In the automotive engine or gyratory crusher, it is customary to use a gear pump, driven by belt or chain connection from the main shaft. Where industrial bearings are involved, however, or where a more considerable volume of cooling medium must be handled, independent means of drive is frequently adopted. This is quite economical where the cooling system is designed to serve a number of machines in stationary service.

Methods of Pre-Heating

The heat exchanger, of course, can be readily reversed as already suggested to enable pre-

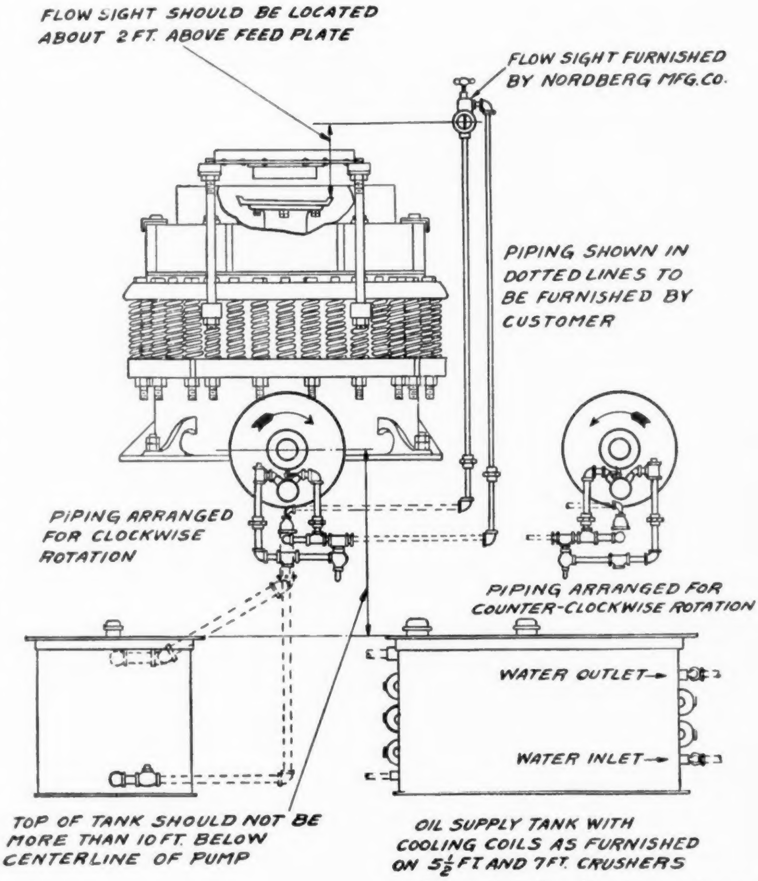
heating of a lubricating oil instead of cooling. Pre-heating is quite important in rock products crushing, where the gyratories operate on circulating oiling systems and often have to start at quite low temperatures. Here steam or hot water heating of the oil in the lubricating system is a decided factor in enabling prompt flow of oil to all moving parts as soon as the machine is started.

Steam is more generally the accepted medium for pre-heating or heat exchanger work. Exhaust steam of from one to ten pounds pressure, having a temperature slightly above the boiling point of water, is especially economical. Where steam is used, the same care is necessary as with water, to assure that there will be no leaks in any of the joints to allow for water contamination of the oil to be heated. Otherwise, with the rise of temperature of this latter, the possibility of emulsification, oxidation and formation of permanent sludge will be accelerated.

RESEARCH INCIDENT TO POUR TEST STANDARDIZATION

Congealment of petroleum lubricants when exposed to low temperatures is due to partial solidification of certain of the hydrocarbon constituents, or separation of paraffin wax crystals in non-dewaxed oils. In such oils this separation of wax is not only indicated by increase in the plasticity of the oil but also visually by development of a cloudy appearance just prior to actual solidification. The effect of cold upon petroleum lubricating oils is not the same as upon simple fluids, such as water, alcohol, glycerine, benzene, etc. The latter have fixed and accurately ascertainable freezing points at which a complete change from the liquid to the solid state takes place, but lubricating oils, which are mixtures of hydrocarbons of various melting points, or freezing points, behave like solutions, and frequently deposit some portion of their constituents before the whole mixture solidifies.

Research incident to study of the pour test of lubricating oils has developed certain very interesting phenomena which can only be explained by change in the inner or molecular structures of such products. As far back as 1924 authorities of the A.S.T.M., in appreciation of this fact, carried on intensive studies to develop a method of test procedure which would give check results. J. B. Rather and H. M. Anderson at that time discussed the proposal to secure uniformity in results by pre-heating the sample to some arbitrarily selected temperature. They regarded this as objectionable because they found that the pour test obtained on pre-heated samples very frequently would depend upon the degree of pre-heating. Furthermore, some oils after pre-heating give results which bear no relation whatsoever to the condition the oil will ultimately attain when stored at ordinary atmospheric temperatures. The purpose of their work was, therefore, to secure uniformity of test regard-



Courtesy of Nordberg Manufacturing Company

Fig. 9—Another unique system for reduction of temperature differences has been developed by the Nordberg Company for the Symons Cone Crusher. Under normal conditions of operation, water is circulated through the coils in the oil storage tank to keep the oil at the proper temperature. Where the machine is subjected to abnormally low temperature starting, however, it is perfectly practicable to pass steam through these coils to warm the lubricant before starting.

less of any previous heat treatment or storage condition, and at the same time to develop a method of test which would give results directly related to the actual condition of the oil in storage.

In this work, eight oils were selected, most of them being products which gave abnormal results by varying heat treatments prior to test. In their preliminary experiments the investigators found that in many cases repetition of the A.S.T.M. procedure on the same sample one or more times caused the oil to return to its final equilibrium with regard to pour point, regardless of previous heat treatment, when the equilibrium was taken to be the condition the oil attained in laboratory storage. They also found, however, that heat treatment of certain oils produced a semi-permanent elevation of pour point which was not rectified by this procedure, and that heat treatment of certain others produced a semi-permanent lowering of the pour point which also was not rectified by the method of test.

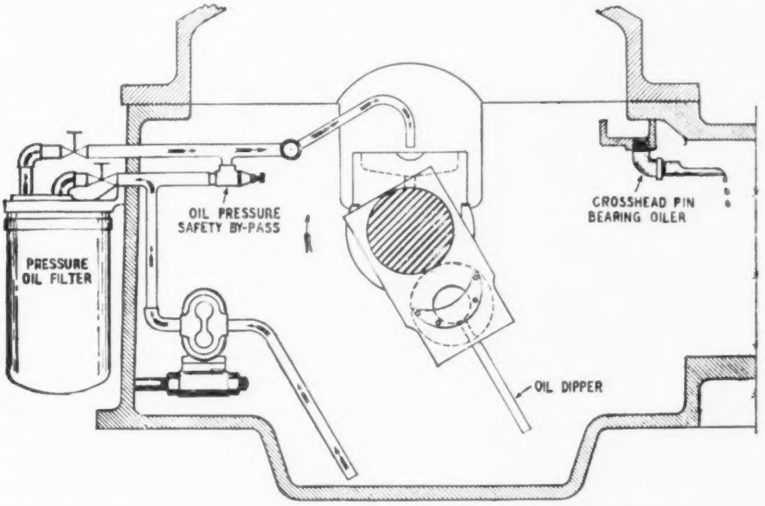
As a result of this work the investigators reached the following conclusions:

"1. If an oil is heated to any specified temperature prior to testing, or immediately prior to receipt by the testing laboratory, the pour point will depend on the temperature to which the oil has been heated.

"2. In all cases the 'high point', that is, the pre-heating temperature at which the maximum possible pour point is attainable, is at about 115 degrees Fahr., and the pour thus obtained more truly represents the ultimate condition the oil will reach in storage than any other.

"3. In order to secure concordant results regardless of any previous heat treatment to which the oil has been subjected prior to receipt by the testing laboratory, it is only necessary to carry out the simple procedure outlined above. No sample, the heat treatment of which has occurred 24 hours previous to testing, requires repetition of the procedure to yield concordant results."

On the basis of this work and more recent developments in studying the behaviour of oils containing pour point depressants, the present methods of test, as accepted by the A.S.T.M. have been formulated. Resultant data developed by Sub-Committee 16 of Committee D-2 of the A.S.T.M. has indicated that by use of a slower rate of cooling it is practicable to ascertain pour tests for oil containing



Courtesy of Ingersoll-Rand Company

Fig. 10—The lubrication system of the power unit of the Ingersoll-Rand gas-engine-driven air and gas compressor is also of interest. In this unit all bearings are continuously flooded with a large volume of oil which is kept clean by a suitable type of filter. Oil circulation from the crankcase through the various bearings is maintained by a gear pump. Pistons, piston pins and crossheads are all lubricated by oil thrown off the crankpins and by direct splash from the dippers on the crank.

pour point depressants, which will be in conformity with actual performance. The revised method of test can also be applied to other types of oils without affecting the results obtained.

Further investigations have proved that any agitation of the oil to be tested, while cooling, may cause false readings. As a result stirring is regarded as contrary to good practice, for where an oil is stirred, it solidifies at a lower temperature than when held stationary. This may be explained on the assumption that the movement of the oil destroys the formation of a fine network of microscopic particles of parafinic bodies which are separating out. This segregation gives the oil a certain support and thereby facilitates solidification. In an analogous way this explanation may apply to the influence of pre-heating; the waxy particles being probably transformed by warming into a very strongly dispersed state, from which it is possible to form a finer and thicker network than in the oil which has not been heated.

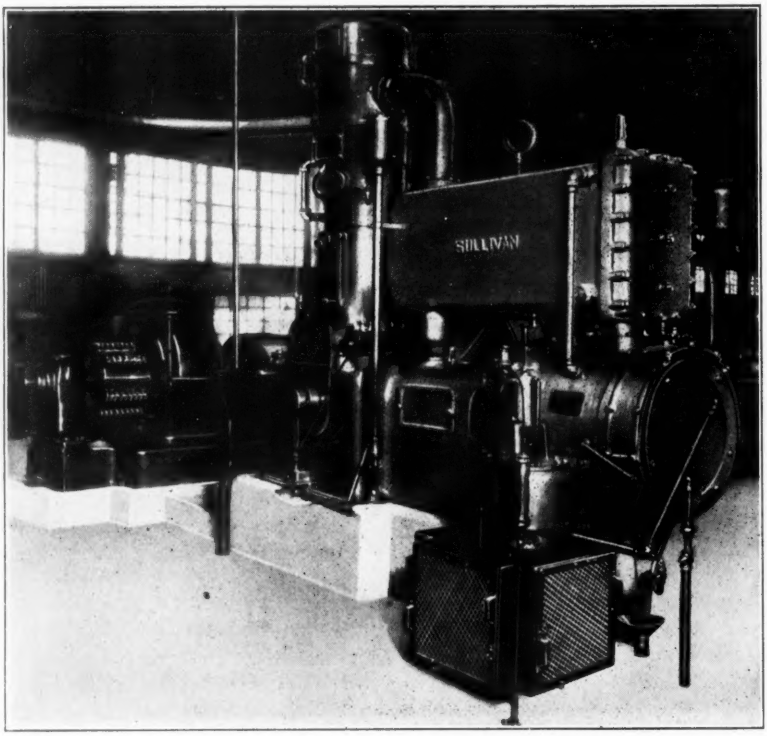
It is of interest to quote the opinion of the A.S.T.M. in regard to the significance of results of cloud and pour tests.

"The cloud point is of value when the oil is to be used in wickfeed service, or when a haze or cloud in the oil above a given temperature would be objectionable for any

reason. However, the test may give misleading results if the oil is not dry, due to the separation of water, and the test should always be interpreted with this fact in mind. In general, the cloud point is of more limited value and narrower range of application than the pour point."

"The pour point gives an indication of the temperature below which it may not be possible to pour or remove an oil from its container, or below which it might be dangerous to use the oil in gravity lubrication systems, where the head tending to produce flow is small. However, it should be borne in mind that the size and shape of the container, the head or force exerted upon the oil, and the nature of its physical structure when solidified, all have an effect upon its tendency to flow. Accordingly, it is self-evident that no single test can be devised which can be taken as a positive and direct measure of the performance of an oil under all conditions of service, and the pour test should be regarded as giving only an indication of what may be expected."

"Consequently, cloud and pour points should be interpreted in the light of actual performance under the particular conditions of use."



Courtesy of Sullivan Machinery Company and American Air Filters Company, Inc.

Fig. 11—Showing an air filter installation on a Sullivan Angle-drive air compressor. Protection of lubrication in air compressor operation is equally as essential as controlled delivery of oil. This is largely accomplished by application of suitable means for removing all abrasive dust and dirt from the air.

COLD ROOM OPERATIONS

Pour test and relative change in viscosity are very important when studying the applicability of straight mineral petroleum lubricants for extremely low temperature operation as in cold room service in the ice cream industry.

Improved methods of handling such products as ice cream have led to an interesting use for the worm reduction gear in connection with conveyor elements. In a modern cold storage room of an up-to-date ice cream plant, the ice cream after it has left the chilling process is put into storage in a cold room, at a temperature ranging in the neighborhood of—40 degrees Fahr. In this room the containers are handled by means of conveyors driven by worm reduction gearing, located directly adjacent to the conveyor elements in the cold room, or outside the room with connections to the conveyor through an extension shaft. Where the reduction gears are located in the cold room and exposed to the prevailing temperatures, it is obvious that the most careful study must be given to the choice of the lubricant, so that it will not only enable easy starting but also afford adequate protection to worm and gear teeth as well as the shaft bearings during operation.

A product of suitable fluidity even at the lowest temperature of the room is required, which will retain, in addition, sufficient of its adhesiveness and lubricating ability to withstand a possible operating temperature rise in the gear case of from 60 to 80 degrees.

Recent study of a variety of lubricants suggested for this purpose has indicated that products of a specially refined crude, with a pour test of —25 degrees Fahr., or better, will best meet these requirements. Actual observations of an experimental gear, subjected to cold room temperatures, has indicated that a sufficient film of lubricants can be formed almost immediately upon the gear teeth, even after as long as 48 hours shut-down.

It is of further interest to note that with such a lubricant it has been possible to bring the gear itself up to speed within from two to four seconds. Under full load operations, this time might be lengthened to a certain extent.

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